

# EARTH OBSERVING SYSTEM MICROWAVE LIMB SOUNDER



## MLS Instrument Operations Status Update

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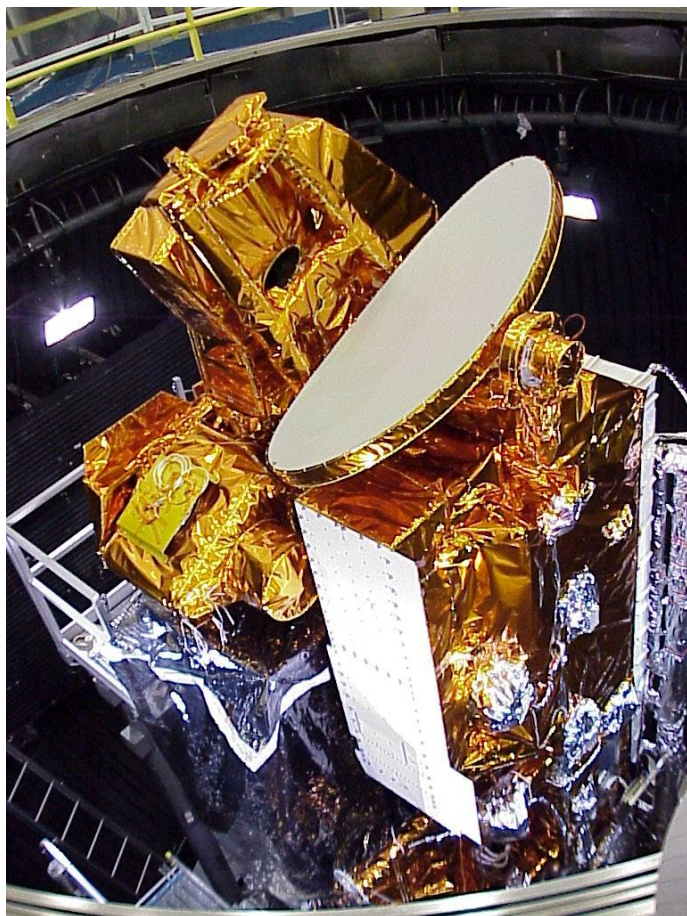
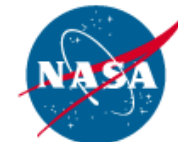
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Greenbelt, MD  
September 15, 2014

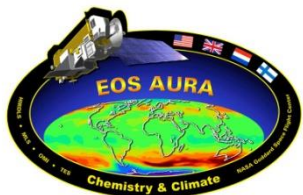




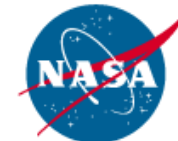
# Overview



- Overall Status
- MLS Significant Events
- Trend Updates
- Longevity Concerns
- Operational Plans
- MLS Team Updates

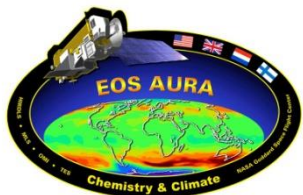


# Overall Instrument Status Mechanisms

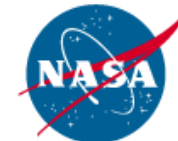


**All 3 MLS mechanisms continue to operate with no signs of life limiting behavior with over 12M scan cycles on the GHz mechanisms**

- **AAA temperature “blips” have been noted in recent years but, after a significant analysis, it has been determined that these are expected**
- **GMEB substitution for GMEA continues to perform perfectly**
- **THz mechanism has been flawless**

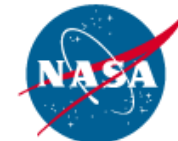
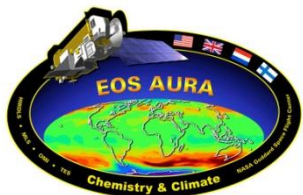


# Overall Instrument Status GHz Module



**All MLS GHz science products continue to be produced 24/7**

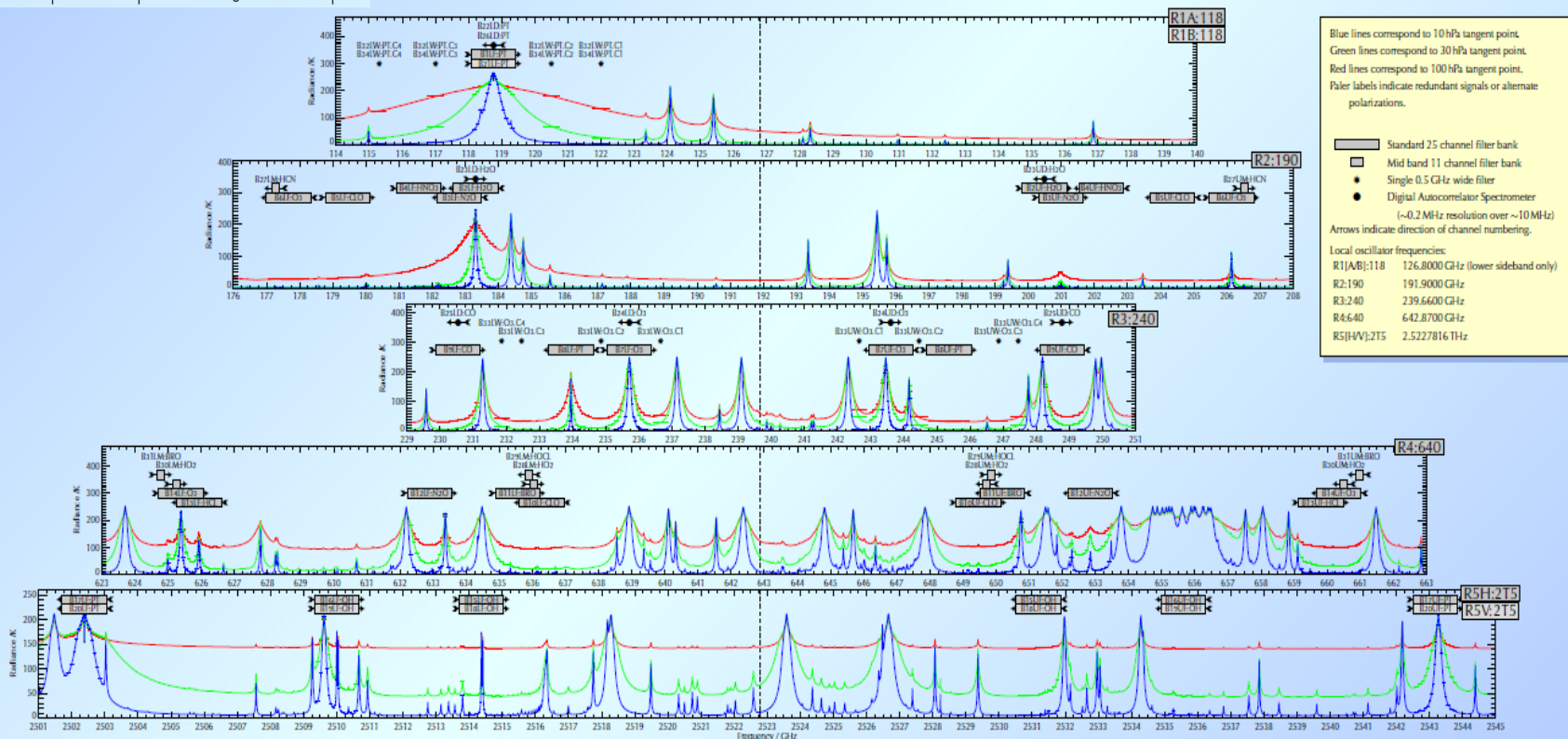
- **MLS HCl and N<sub>2</sub>O products have been shifted from their original signal sources to alternate sources due to speculated HBT (transistor) issues which were identified and accepted as a prelaunch risk**
- **Using alternate signal sources does result in some degradation in the sensitivity and accuracy of these two products**
- **The HCl product was shifted from Band 13 to Band 14 in February 2006**
- **The N<sub>2</sub>O product was shifted from Band 12 to Band 3 in August 2013**
- **The next 2 slides detail how we are able to generate the HCl and N<sub>2</sub>O products despite problems with the HBTs**
- **Overall, the MLS instrument continues to perform very well**



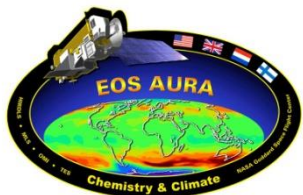
# Thermal Emissions Spectral Lines and MLS Filterbank Coverage

June 9, 2003. Nathaniel Livesey  
Spectroscopic data provided by Mark Filipiak

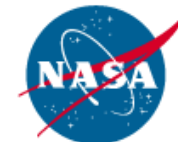
## EOS MLS Spectral Coverage (split sideband)



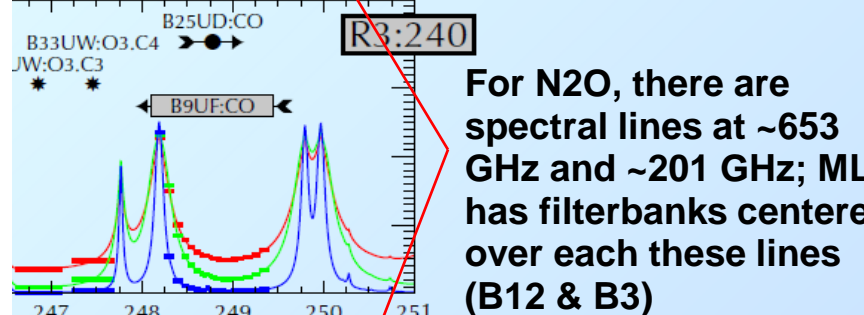
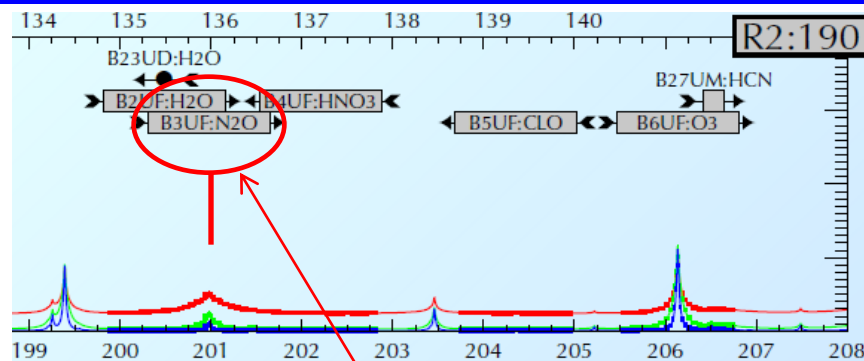
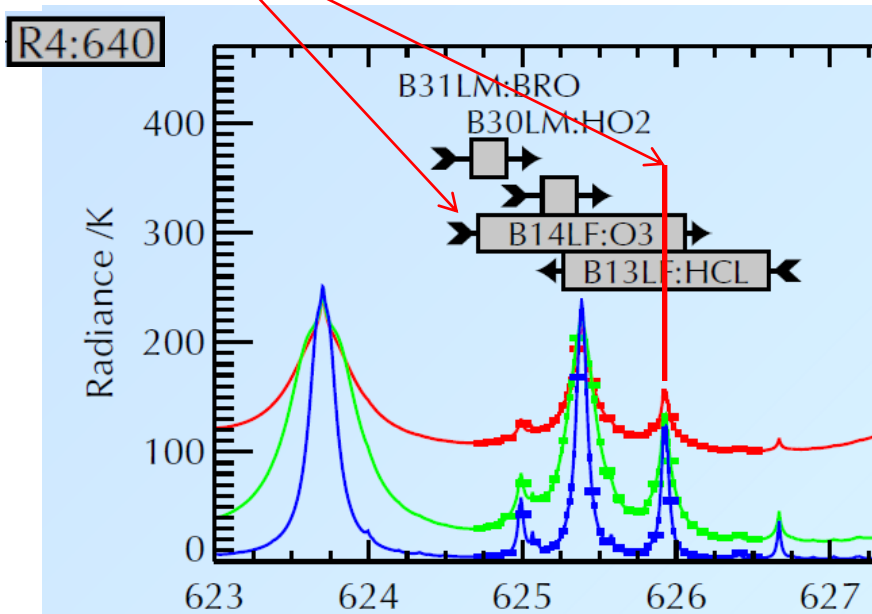
June 9, 2003. Nathaniel Livesey  
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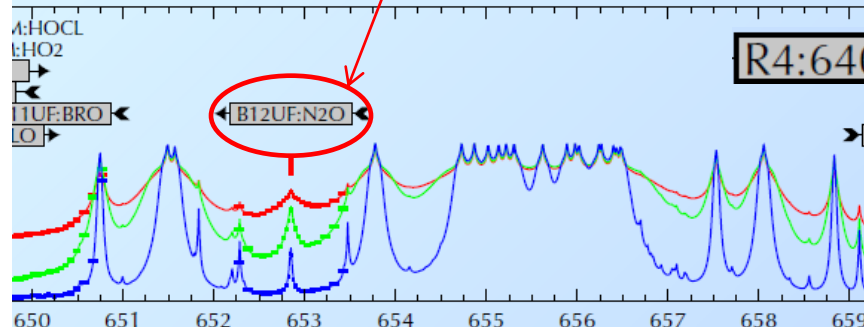
# Multiple Paths to Monitor Some Signals



Band 14 filterbank is centered over the O<sub>3</sub> spectral line but it extends enough to also measure the Band 13 HCl line

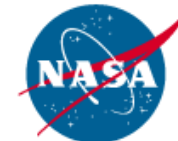


For N<sub>2</sub>O, there are spectral lines at ~653 GHz and ~201 GHz; MLS has filterbanks centered over each these lines (B12 & B3)



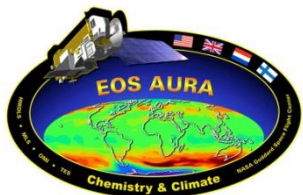


# Overall Instrument Status THz Module



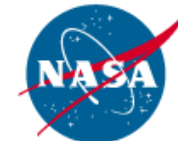
**After exceeding its lifetime requirement by 3x, the THz OH measurements are being made ~ 1 month per year to establish a long term OH trend**

- **THz Module Laser Local Oscillator (LLO) has remained in lock around 50% of the time on average for the 2014 measurement period; this is significantly lower than the ~80% in lock status from 2013**
- **Current plan is to keep the THz hardware on for ~40 days with a planned power down on around Sept. 30**
- **This date is subject to review pending LLO performance over the next several weeks**



# MLS Instrument Significant Events

## Oct. 2012 – Sep. 2013



- **SIF2 Configuration Register Corruption** - Oct. 17, 2012
  - Occurred in South Atlantic Anomaly (SAA)
  - Suspected cause: SEU
- **SIF2 Reconfiguration Recovery** - Oct. 25, 2012
  - Recovery completed by resending configuration commands to the SIF2 electronics
- **Band 27 Saturation Test** - Feb. 12, 2013
  - Test confirmed we had room to adjust the Band 6 attenuator without saturating Band 27
  - Attenuator adjustment boosted Band 6 counts away from noise margin levels for at least several years

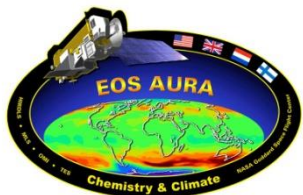


# MLS Instrument Significant Events

## Oct. 2012 – Sep. 2013, continued



- **Moon Track 8 measurement** **- Mar. 29, 2013**
  - Provides long term primary reflector stability information
  - Small increases in ohmic loss have been observed but overall stability of reflector is excellent
  
- **Band 12 Substitution Test** **- Apr. 22, 2013**
  - Diagnostic to determine area of signal chain which was causing Band 12 science counts to drop
  - Suspected cause of Band 12 science count loss is an HBT transistor issue similar to Band 13
  
- **THz Module 2013 Annual Measurement** **- Aug. - Sep. 2013**
  - THz laser performed better than expected in the beginning of the measurement period but exhibited an accelerated degradation in the last few days



# MLS Instrument Significant Events

Oct. 2013 – Sep. 2014

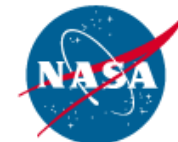


- **SIF4 Band 12 Power Down** - Aug. 06, 2013
  - Band 12 signal was degrading and was powered off after decision to use Band 3 for N<sub>2</sub>O product generation
- **GHz Switch #4 to monitor Band 21 vs. Band 12** - Sep. 16, 2013
  - Moved switch to collect useful P-T data since Band 12 is off
- **SIF2 Configuration Register Corruption & Recovery** - Sep. 16, 2013
  - Occurred in South Atlantic Anomaly (SAA)
  - Suspected cause: SEU
  - Recovery within same day after identifying this as repeat of the previous SIF2 anomaly
- **Band 7 Dual Monitor Test** - Dec. 12, 2013
  - Diagnostic to determine area of signal chain which was causing features seen in B7 L0 plots



# MLS Instrument Significant Events

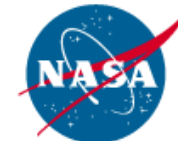
## Oct. 2013 – Sep. 2014, continued



- **MLS Moon Track 9 measurement** - Mar. 18, 2014
  - Provides long term primary reflector stability information
  - Overall stability of reflector remains excellent
- **Pressure-Temperature Dual Monitor Test** - Dec. 12, 2013
  - Additional diagnostic to determine which area of the signal chain was causing features seen in Band 7 L0 plots
- **THz Module 2014 Annual Measurement** - Aug. - Sep. 2014
  - THz LLO performance has not been as good as last year
  - Averaging around 50% of the time in lock which is the maximum possible percentage of useful profiles; actual number of useful profiles will be less
- **SIF4 Configuration Register Corruption & Recovery** - Aug. 19, 2014
  - Occurred in South Atlantic Anomaly (SAA)
  - Suspected cause: SEU
  - Recovery via reconfiguration of SIF4 electronics within hours after identifying this anomaly as being similar to the SIF2 anomalies
  - Some adverse thermal effects on Bands 10 and 29; details to follow



# MLS Close Watch Trends



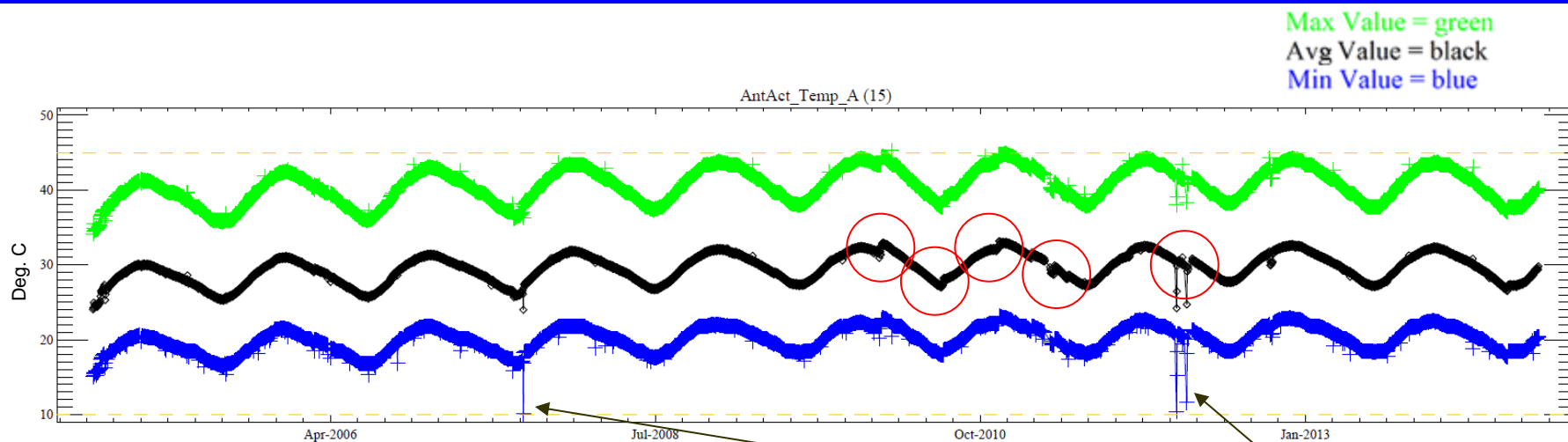
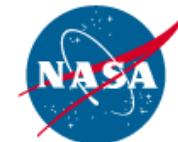
## MLS AAA temperature trend

- **Several occurrences of a small temperature increase ( $< 1\text{ }^{\circ}\text{C}$ ) have been noted in the Antenna Actuator Assembly temperature beginning in Jan. 2010**
- **After each event, the temperature has drifted back towards its norm**
- **Subsequent events appear to be more frequent but with less of a temperature excursion from the norm**
- **Suspected cause is slightly larger than usual wear product in the mechanism travel that is being reduced over time**
- **Per the CogE, the AAA felt washer “is probably just losing fibers” as is expected. “We have lots of evidence of fiber shedding from these felt washers”**
- **No science data impact from this “anomaly”**



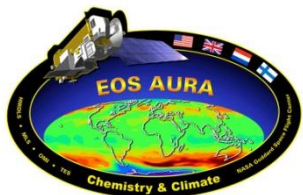
# MLS Close Watch Trends

## AAA temperature; full mission trend



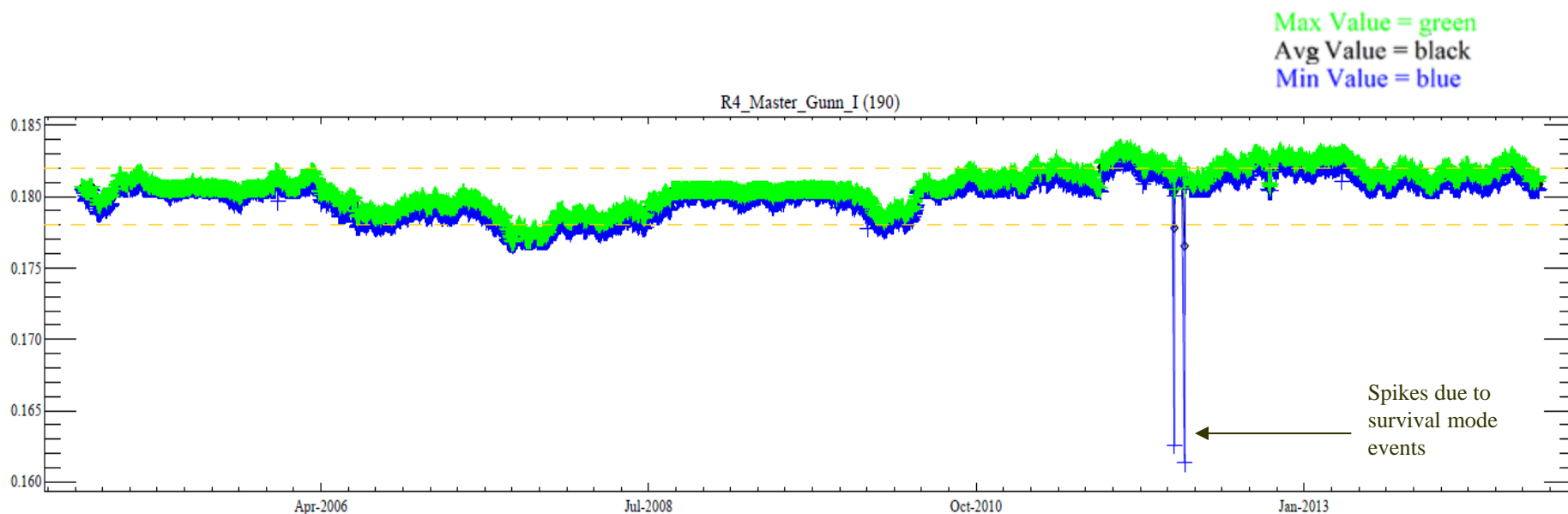
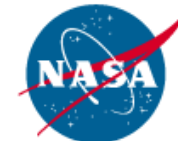
Spikes due to survival mode events and AAA parked

- One set of data points per mission day
  - Each set contains a max, min, and an average value
- The dashed yellow “guide lines” on these plots are arbitrary in value and are based on the launch and activation period
- A sudden change in any telemetry point will always draw our attention but the overall behavior of this temperature does not have us concerned

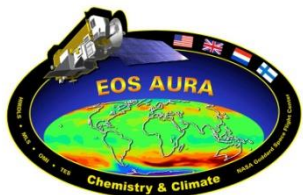


# MLS Close Watch Trends

## R4 Master Gunn Current, Full Mission Trend

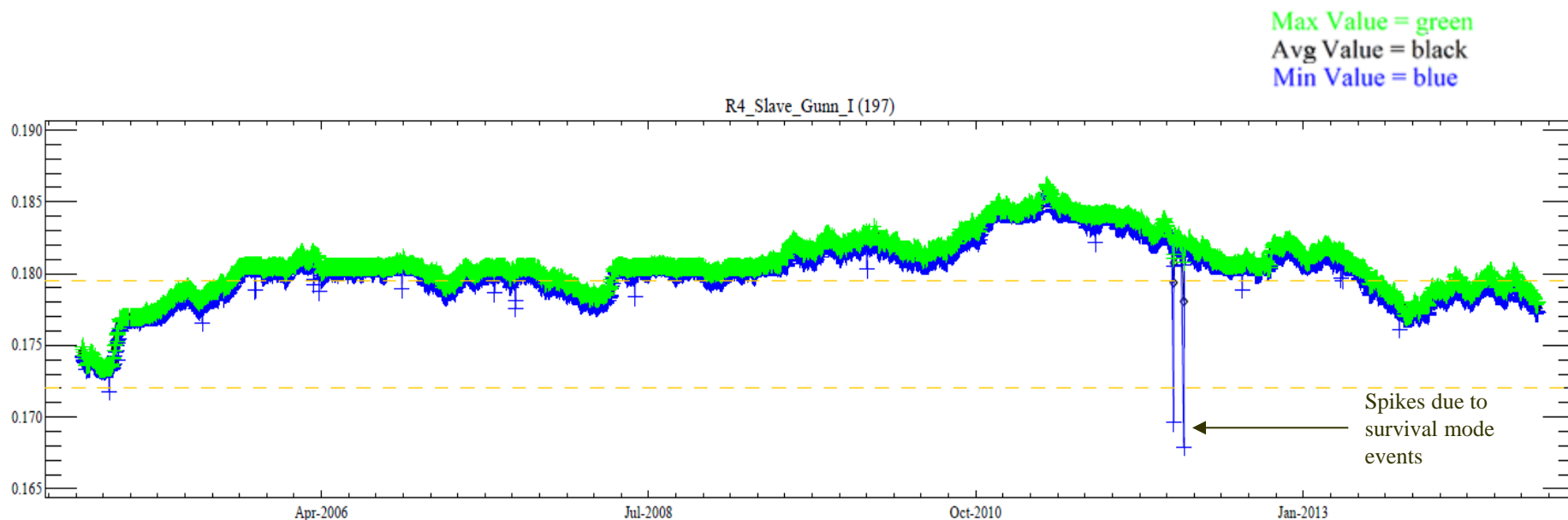
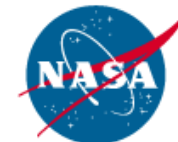


- The R4 Master Gunn current has decreased from near mission high levels over the past month
- We continue to monitor this point closely with daily text messages



# MLS Close Watch Trends

## R4 Slave Gunn current, full mission trend

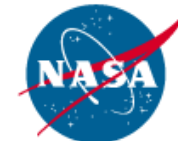


- The R4 Slave Gunn current has remained well within the nominal mission range over the past year

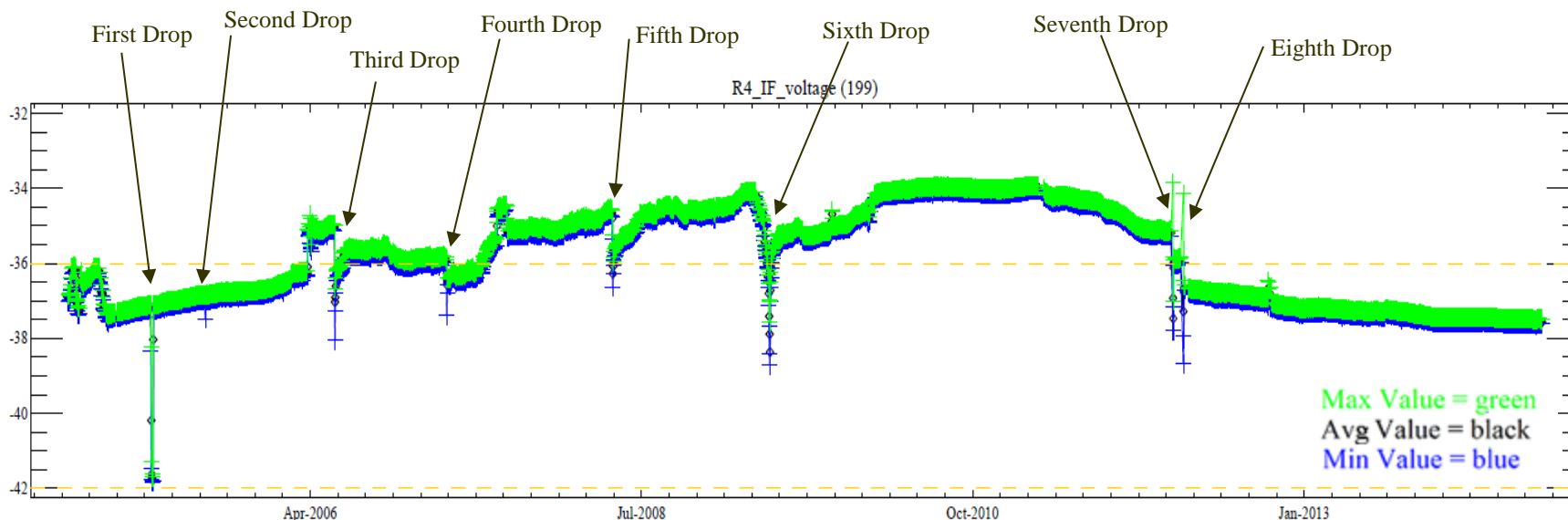


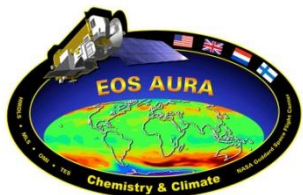
# MLS Close Watch Trends

## R4 Receiver LO IF Power Monitor, full mission trend



- The MLS 640 GHz receiver (R4) LO IF power telemetry has temporarily dropped, with no apparent cause, on six occasions but has recovered each time
- There were also two small drops in 2012 that have been associated with survival mode events
- This closely monitored telemetry point has remained stable over the past 2 years
- It is believed that these drops are only an artifact in telemetry
- These drops have had no observable effect in the science data



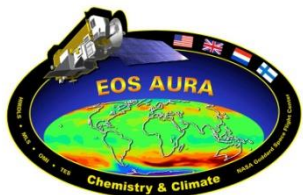


# MLS Close Watch Trends

Bands 10 and 29 (CIO and HOCl)

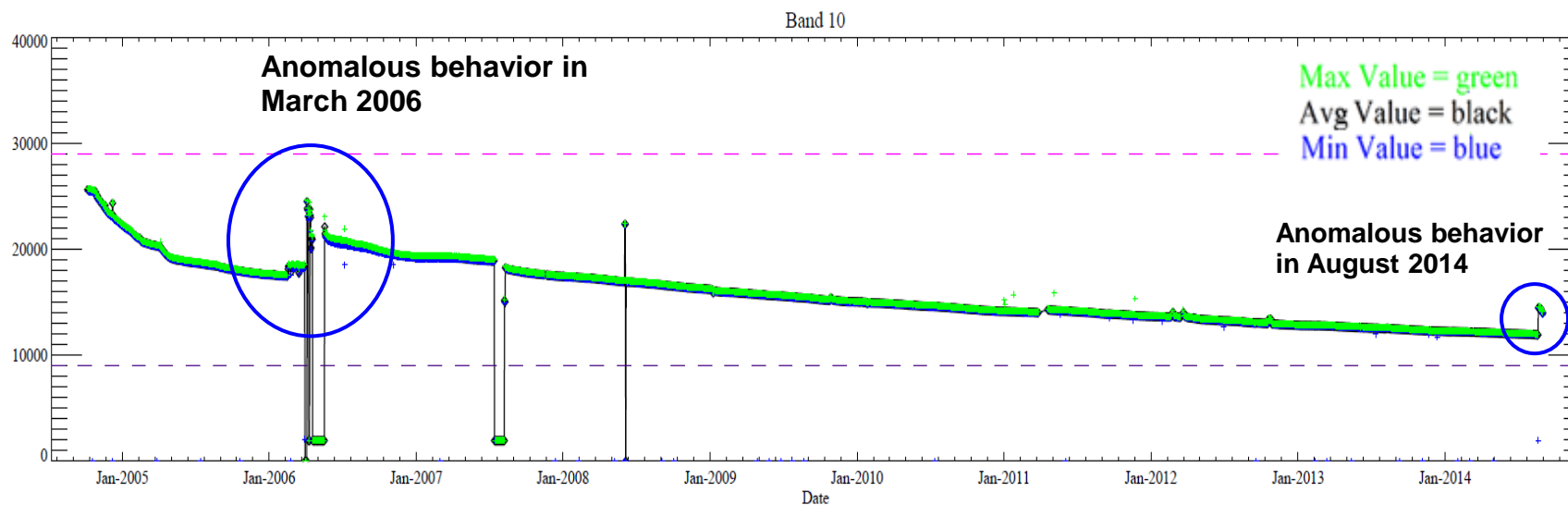


- Bands 10 and 29, fed from a common signal in SIF4, exhibited anomalous behavior/thermal sensitivities in 2006 leading to operational practices which minimize thermal cycling of the Band 10/29 specific hardware
- Bands 10 and 29 have remained stable from May 2006 until a recent SIF4 configuration register anomaly which occurred in August 2014
- During this anomaly, SIF4 temperatures dipped by 3 - 4 degrees and the anomalous behavior in Bands 10 and 29 returned
- At this point, the erratic changes in Bands 10 and 29 have subsided and the counts are trending back towards their pre anomaly values
- Bands 10 and 29 have also experienced three larger ( $> 30^{\circ} \text{C}$ ) temperature cycles during survival mode transitions with no adverse effects



# MLS Close Watch Trends

Band 10 (CIO), full mission trend, one data set per day

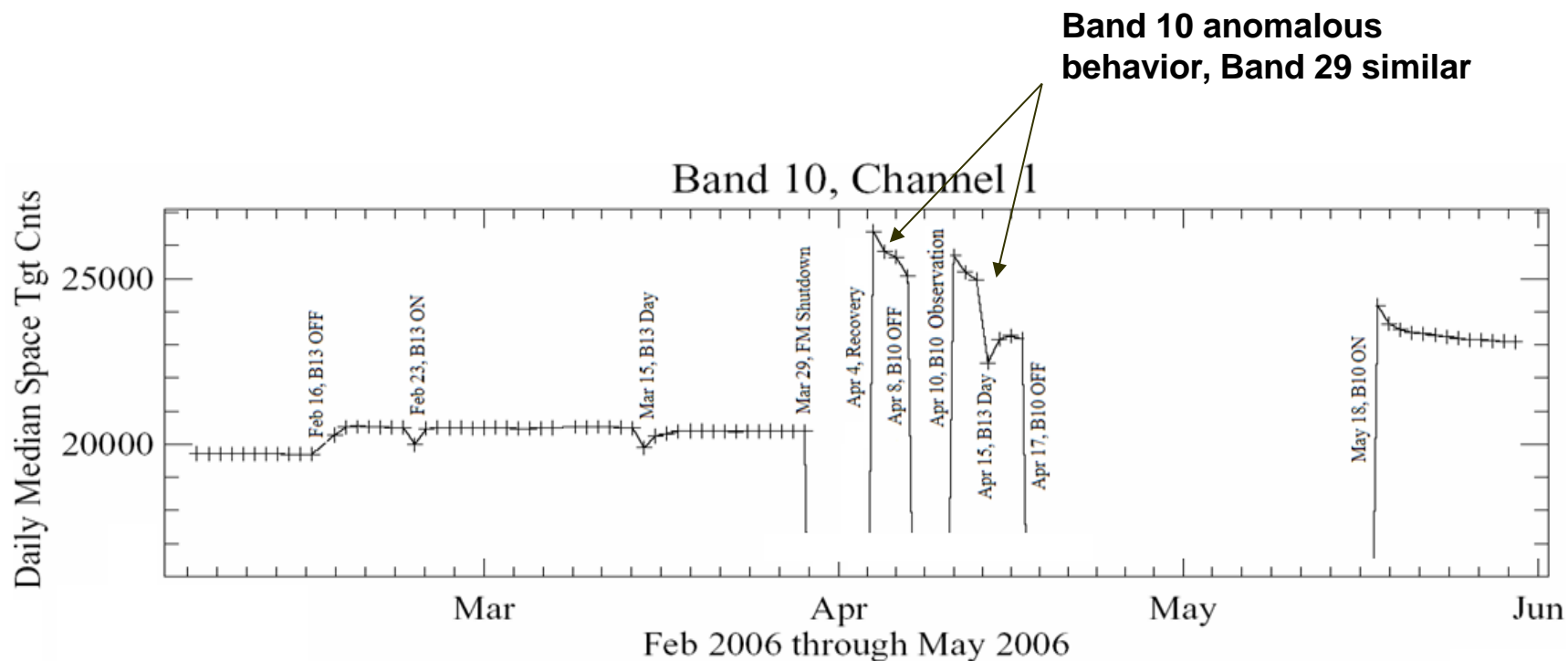
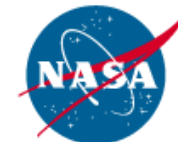




# MLS Close Watch Trends

Band 10 Focus: Feb. to May, 2006

One data point per day

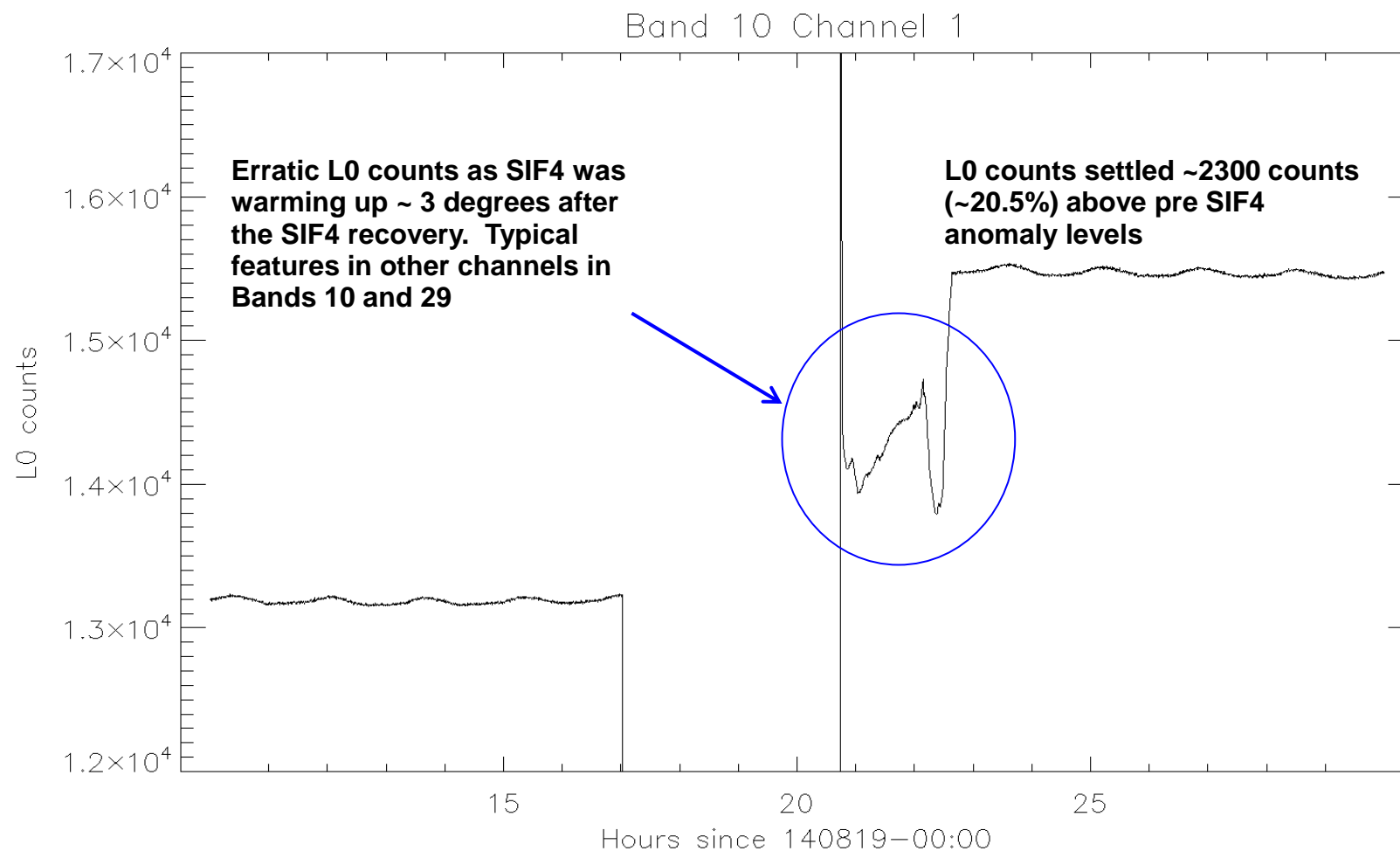
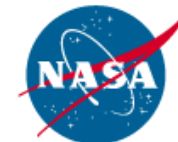




# MLS Close Watch Trends

Band 10 Focus: August 19 - 20, 2014

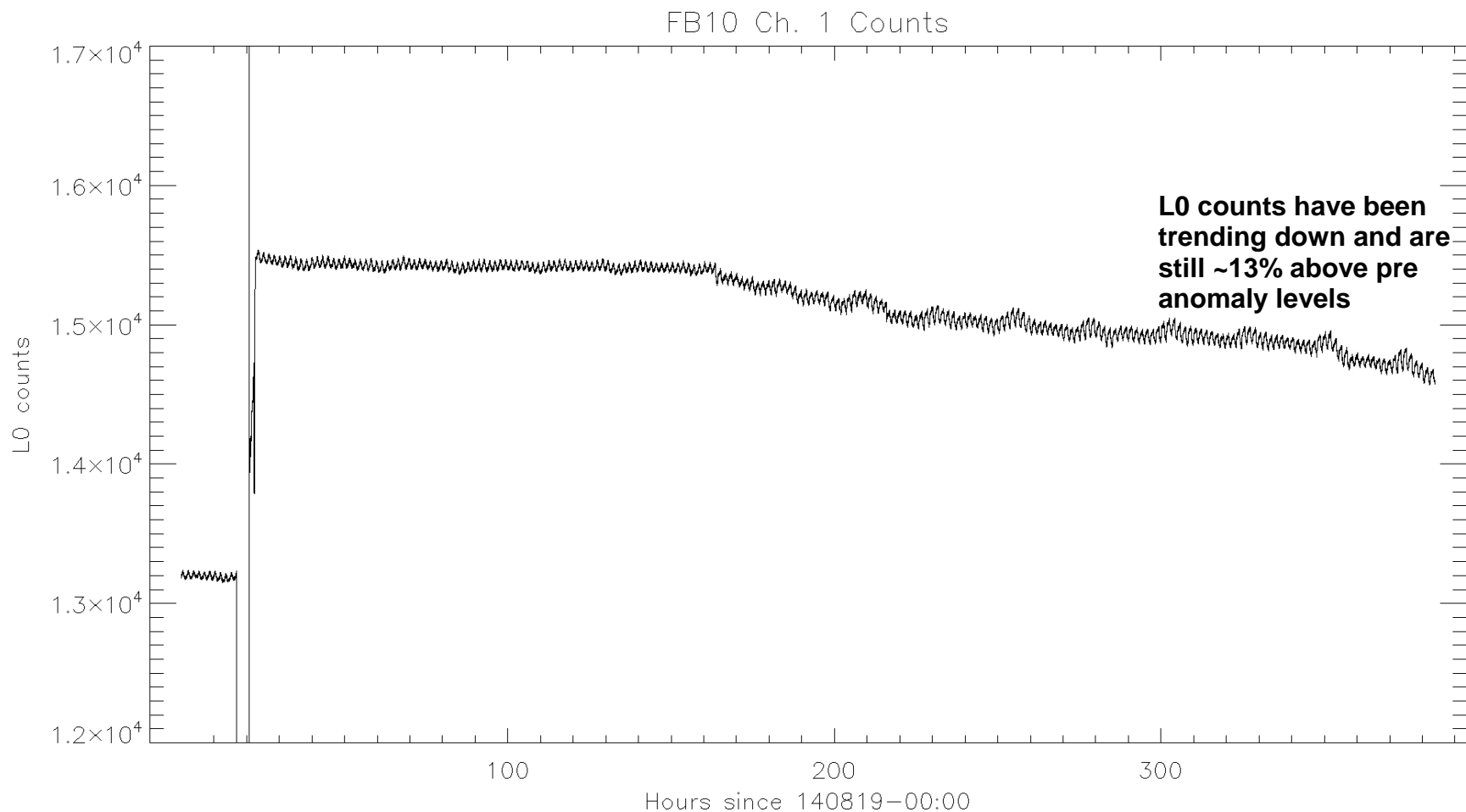
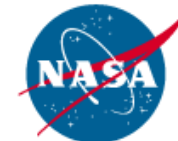
One data point per MAF

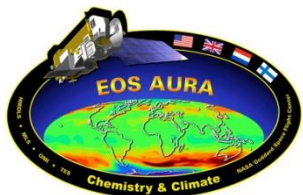




# MLS Close Watch Trends

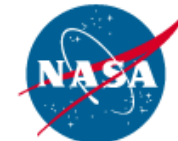
Band 10 Focus: Hours since August 19, 2014  
One data point per MAF



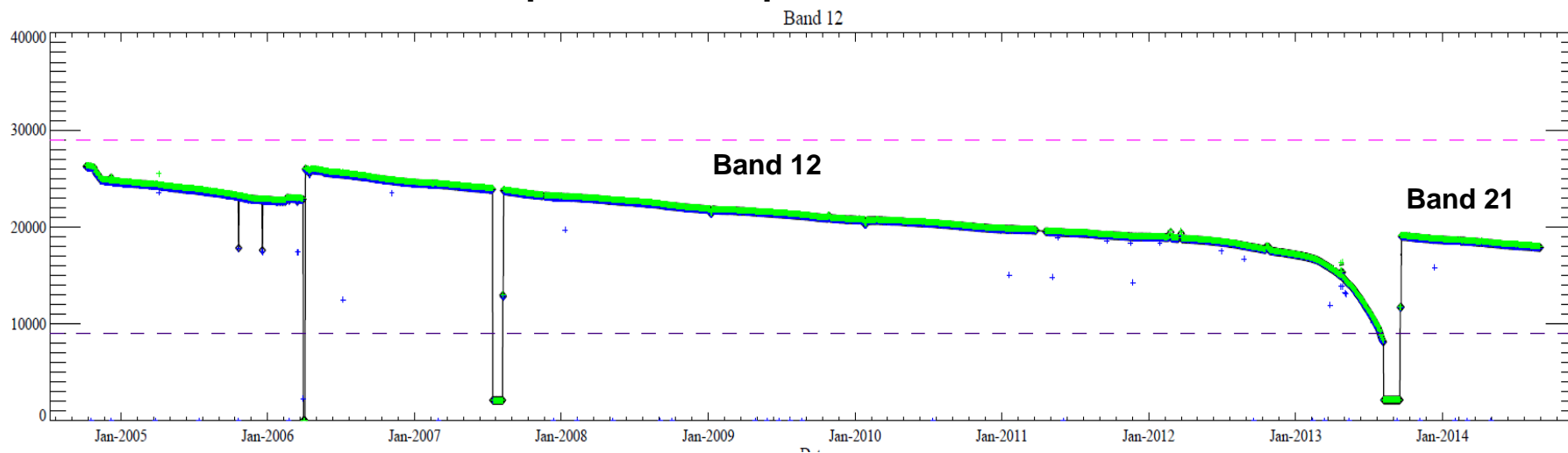


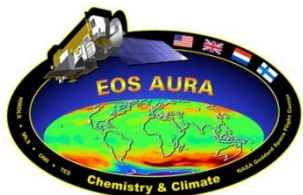
# Trend Updates

## Band 12 (N<sub>2</sub>O), full mission trend

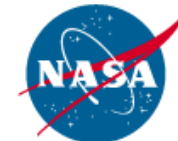


- Band 12 specific electronics were powered down on Aug. 06 2013 after the L0 science count rate of decline had accelerated over the course of a year
- MLS N<sub>2</sub>O product is now being generated using the Band 3 N<sub>2</sub>O spectral line
- Filterbank 12 spectrometer is now being used to monitor Band 21, which covers the 118 GHz pressure-temperature line

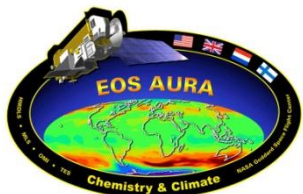




# Operational Plans



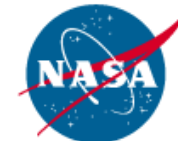
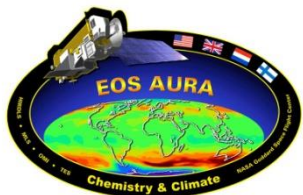
- **Continue with MLS routine and calibration activities**
  - AAA Reconditionings
  - Spectral Baseline updates
  - Moon Tracking Scan #10
    - March 06, 2015 23:04:03 with a yaw angle of  $\sim 0.033$  deg.
- **Bands 10 and 29 (ClO and HOCl)**
  - Minimize thermal cycling of Bands 10 and 29 where reasonable
- **Band 13 (HCl)**
  - We will choose our next Band 13 measurement carefully knowing that we may only have one measurement period left
- **THz Module (OH)**
  - Continue current measurement through end of Sept. (tbr)
  - Next measurement in August 2015



# EOS MLS Contact Information



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<b>Robert Jarnot</b> (Instrument Scientist)	(818) 354-5204	(818) 653-9266	N/A	<a href="mailto:robert.f.jarnot@jpl.nasa.gov">robert.f.jarnot@jpl.nasa.gov</a>
<b>Rick Cofield</b> (MLS FOV Scientist)	(818) 354-2501	N/A	N/A	<a href="mailto:rick.cofield@jpl.nasa.gov">rick.cofield@jpl.nasa.gov</a>
<b>Elmain Martinez</b> (Project Manager)	(818) 354-4053	(626) 429-9250	(818) 353-8775	<a href="mailto:elmain.martinez@jpl.nasa.gov">elmain.martinez@jpl.nasa.gov</a>
<b>Nathaniel Livesey</b> (Principal Investigator)	(818) 354-4214	(818) 219-6394	N/A	<a href="mailto:nathaniel.j.livesey@jpl.nasa.gov">nathaniel.j.livesey@jpl.nasa.gov</a>

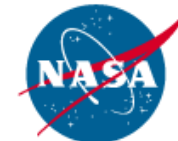


## Backup Slides

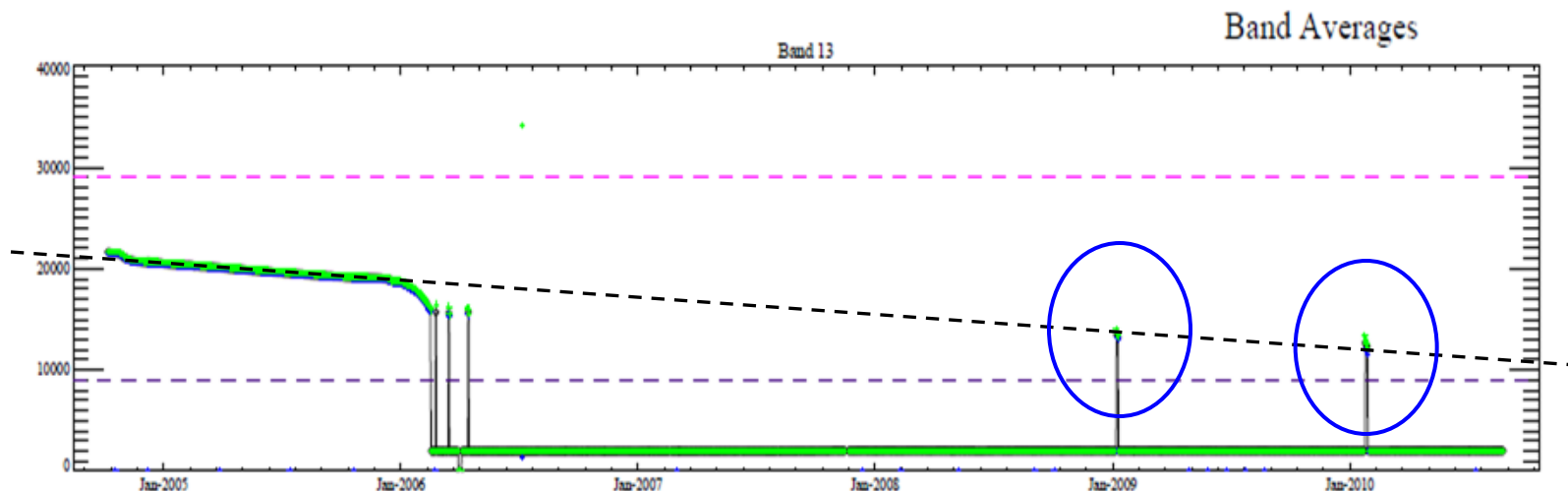


# Trend Updates

## Band 13 (HCl)



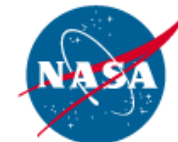
- Band 13 was powered off in 2006 to conserve life due to a suspected HBT (transistor) issue and Band 14 has since been used to measure HCl
- Spot check measurements of Band 14 HCl were made using Band 13 in January of 2009 and 2010
- During the last measurement Band 13 exhibited signs which suggest that it is close to its end of life
- We will choose our next Band 13 measurement carefully knowing that we may only have one measurement period left



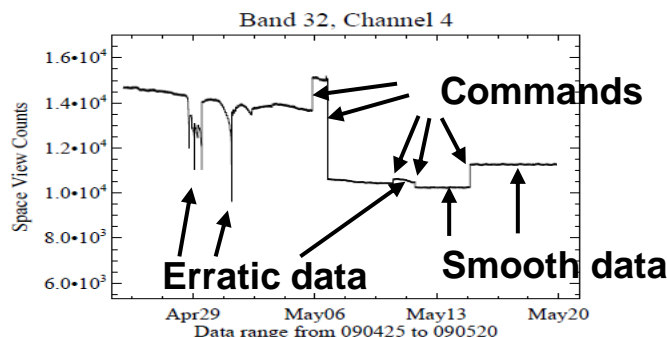
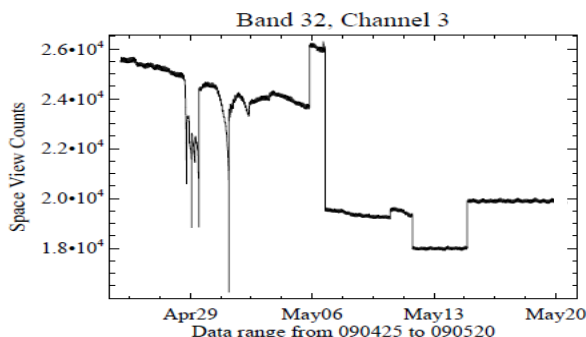
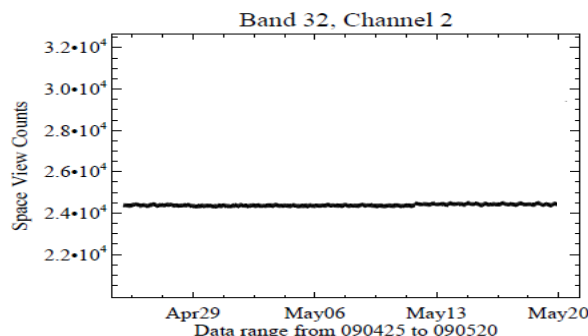
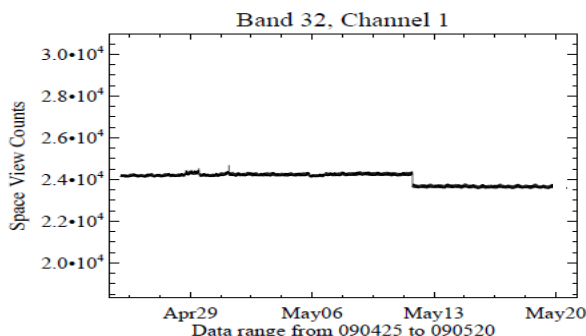


# Trend Updates

## Band 32 (Temperature and Pressure), April – May 2009



- Band 32 Channels 3 and 4 have shown erratic behavior on 2 occasions
- During the second occasion (shown below), commands were sent to locate and isolate the anomalous hardware
- Band 32 has remained stable since May 2009

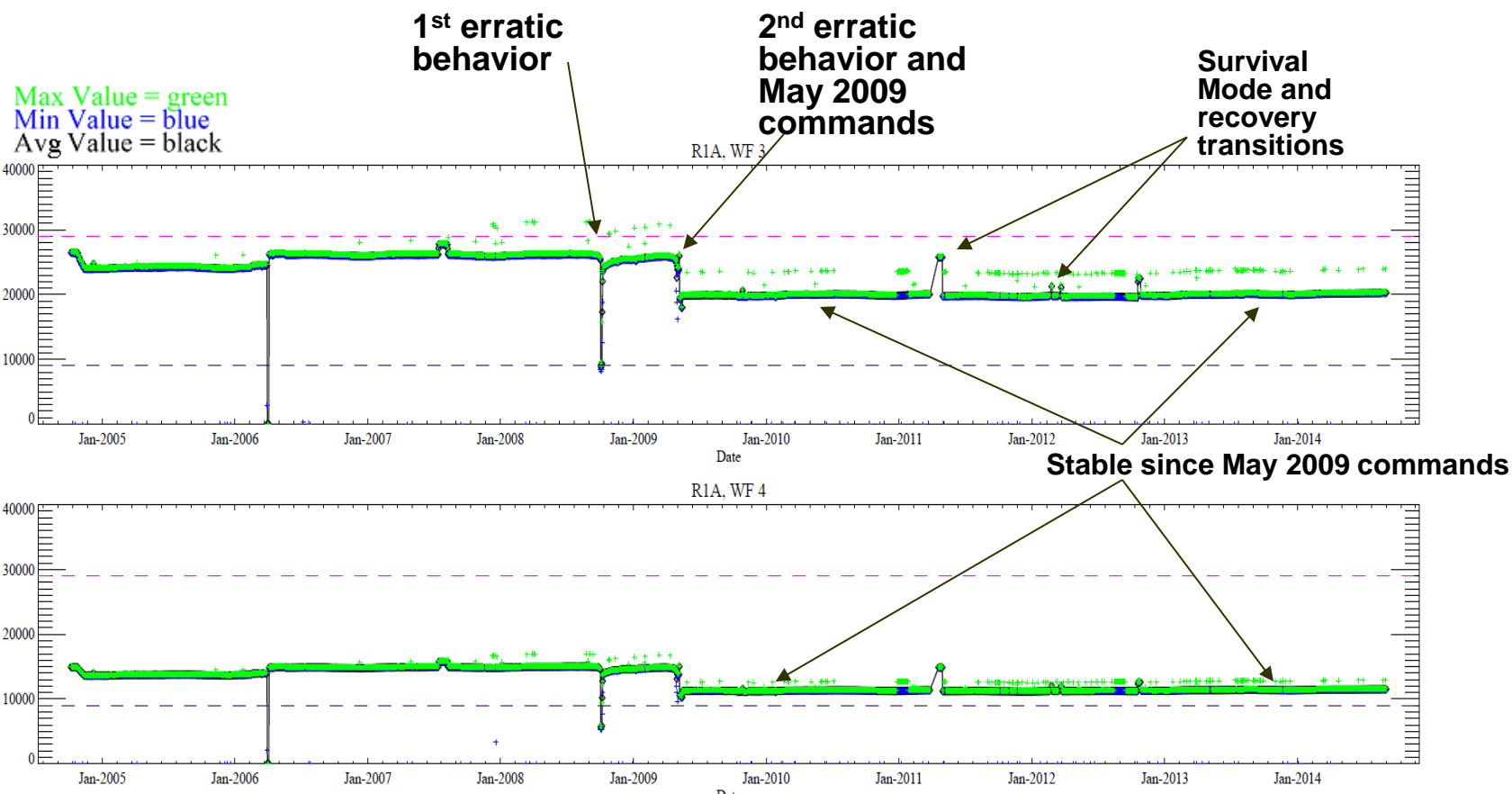
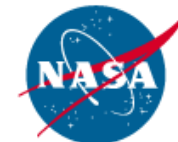




# Trend Updates

## Band 32 Channels 3 and 4

### Full mission trend





# Longevity Concerns

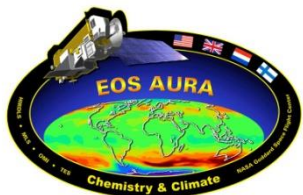
## Spectrometer Module



- The Band 27 Saturation Test confirmed we had room to adjust the Band 6 attenuator without saturating Band 27
- Attenuator adjustment boosted Band 6 counts away from noise margin levels for at least several years

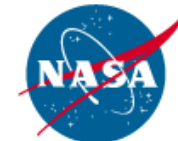
**The potential tradeoff decision listed below is no longer necessary**

- Band 6 and Band 27 share a common signal source
  - Band 6 signal levels have been decreasing slowly (due to voltage regulator issue) while Band 27 has held steady
  - We have sufficient attenuation adjustment available to boost Band 6 levels as needed, but, boosting Band 6 will also boost Band 27 and may cause it to enter saturation levels
  - Based on current trends, we have ~ 6 months to 1 year before a few channels in Band 6 reach minimal levels and a Band 6/ Band 27 tradeoff decision may be necessary



# Longevity Concerns

## Spectrometer Module



**The magnitude of many science signals from the spectrometer module have been decreasing slowly since launch due to a known issue with a certain batch of voltage regulators**

- Existing test data on these components is insufficient to project remaining life.**
- While we are aware of this performance degradation, none of the more than 5 dozen of these parts have failed since launch**
- Current gain settings are good for the foreseeable future**